suited from their labours. The brass tube, strengthened at the bearing points by strong truly-turned collars, rotates in the cast-iron cradle q attached to the declination axis. a is the eye-piece fixed in that axis, b the micrometer for reading both scales.

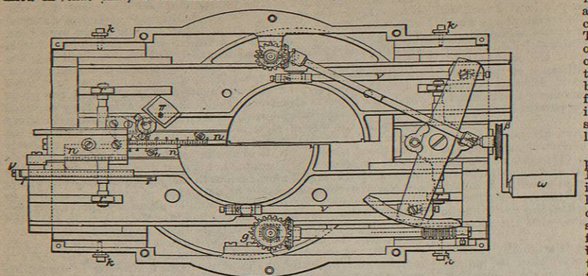

Fig. 35.

c, d are telescopes for reading the position circle p, e the handle for quick motion in position angle, f the slow motion in position angle, g the handle for changing the separation of the segments by acting on the bevel-wheel g' (fig. 35). h is a milled head connected by a rod with h' (fig. 35), for the purpose of interposing at pleasure the prism π in the axis of the reading microscope; this enables the observer to view the graduations on the face of the metallic thermometer $\tau\tau$ (composed of a rod of brass and a rod of zinc). i is a milled head connected with the wheel $i'i'$ (fig. 35), and affords the means of placing the screen s (fig. 34), counterpoised by w over either half of the object-glass. k clamps the telescope in declination, n clamps it in right ascension, and the handles m and l provide slow motion in declination and right ascension respectively.

The details of the interior mechanism of the "head" will be almost evident from fig. 35 without description. The screw, turned by the wheels at g', acts in a toothed arc, whence, as shown in the figure, equal and opposite motion is communicated to the slides by the jointed rods v, v. The slides are kept firmly down to their bearings by the rollers r, r, r, r, attached to axes which are, in the middle, very strong springs. Side-shake is prevented by the screws and pieces k, k, k, k. The scales are at n, n; they are fastened only at the middle, and are kept down by the brass pieces t, t.

A similar heliometer was made by the Repsolds to the order of Lord Lindsay for his Mauritius expedition in 1874. It differed only from the three Russian instruments in having a mounting by the Cookes in which the declination circle reads from the eye-end.[1] This instrument was afterwards most generously lent by Lord Lindsay to Gill for his expedition to Ascension in 1877.[2]

These four Repsold heliometers proved to be excellent instruments, easy and convenient in use, and yielding results of very high accuracy in measuring distances. Their slow motion in position angle, however, was not all that could be desired. When small movements were communicated to the handle e (fig. 34) by the tangent screw f, acting on a small toothed wheel clamped to the rod connected with the driving pinion, there was apt to be a torsion of the rod rather than an immediate action. Thus the slow motion would take place by jerks instead of with the necessary smoothness and certainty. When the heliometer part of Lord Lindsay's heliometer was acquired by Gill in 1879, he changed the manner of imparting the motion in question. A square toothed racked wheel was applied to the tube at r (fig. 34). This wheel is acted on by a tangent screw whose bearings are attached to the cradle; the screw is turned by means of a handle supported by bearings attached to the cradle, and coming within convenient reach of the observer's hand. The tube turns smoothly in the racked wheel, or can be clamped to it at the will of the observer. This alteration and the new equatorial mounting have been admirably made by Grubb; the result is completely successful. The instrument so altered has been in constant use at the Cape Observatory since March 1881 in determining the parallax of the more interesting southern stars.

Still more recently the Repsolds have completed a new heliometer for Yale College, New Haven, United States. The object-glass is of 6 inches aperture and 98 inches focal length. The mounting, the tube, objective-cell, slides, &c., are all of steel.[3] The instrument is shown in fig. 36. The circles for position angle and declination are read by micrometer microscopes illuminated by the lamp L; the scales are illuminated by the lamp l. T is part of the tube proper, and turns with the head. The tube V, on the contrary, is attached to the cradle, and merely forms a support for the finder Q, the handles at f and p, and the moving ring F. The latter gives quick motion in position angle; the handles at p clamp and give slow motion in position angle, those at f clamp and give slow motion in right ascension and declination. a is the eye-piece, b the handle for moving the segments, c the micrometer microscope for reading the scales and scale micrometer, d the micrometer readers of the position and declination circles, e the handle for rotating the large wheel E which carries the screens. The hour circle is also read by microscopes, and the instrument can be used in both positions (tube preceding and following) for the elimination of the effect of flexure on the position angles.

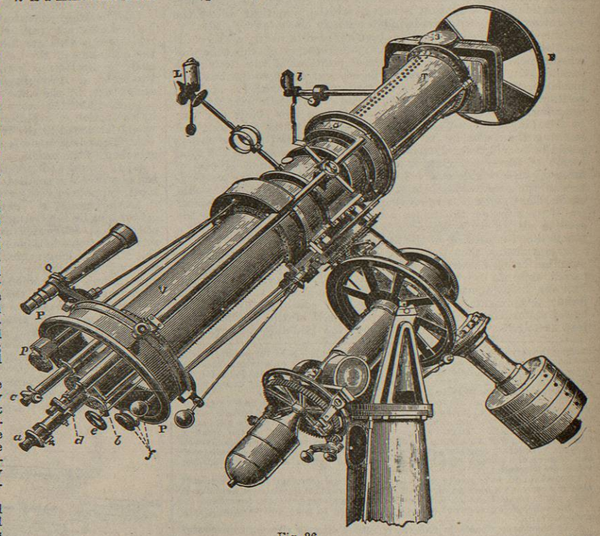

Fig. 36.

[1] For a detailed description of this instrument see *Dunecht Publications*, vol. II.

[2] *Mem. Royal Astronomical Society*, vol. xlvi. pp. 1–172.

[3] The primary object was to have the object-glass mounted in steel cells, which more nearly correspond in expansion with glass. It became then desirable to make the head of steel for sake of uniformity of material, and the advantages of steel in lightness and rigidity for the tube then became evident.

There is very little left to criticize in this instrument. It embraces the results of all knowledge and experience on the subject to the present time. In one point, however, modern heliometers have a disadvantage compared with the older forms. A great advance in accuracy was, no doubt, made when the screw was abandoned as a means both of moving and measuring the displacement of the slides.[1] But it is obviously much quicker to read and record the indication of one screw-head than to bisect two or four scale-divisions and enter the corresponding readings. Auwers, in his researches on the parallax of 61 Cygni,[2] was able, with the Königsberg heliometer, to make forty pointings in about an hour; it is quick work to make sixteen pointings (reading two divisions on each scale at each pointing) with the modern heliometer in the same time, when attention is paid to the desirable reversals of the segments and of the position circle and the resettings in right ascension and declination. Now time during opportunities of good definition (or otherwise)[3] is too precious to be sacrificed, if it can be saved even by ten-fold labour afterwards. Carrington[4] has suggested the possible use of photography to record the readings of astronomical circles, and since his day "Swan lights" and "sensitive dry plates" seems to have brought his suggestion within the range of practice. A special microscope, fitted with an aplanatic photographic objective and a well-contrived carrier, might be made automatically to expose a different part of a narrow dry plate, by mere pressure or turning of a button after each bisection. Each plate might easily record the sixteen bisections which constitute a complete measure of two pairs of stars (as in a parallax determination). As it is only necessary to photograph two divisions of each scale, the photographic enlargement of these divisions need only be limited by the sensitiveness of the plates and the power of the illumination to produce a picture in a conveniently short space of time. The plates employed at night could be conveniently developed the following day and measured with a special apparatus at any convenient time and with almost any desired accuracy. Were such a system reduced to practice it would at least double, perhaps treble, an observer's possible output of work.

Gill has introduced a powerful auxiliary to the accuracy of heliometer measures in the shape of a reversing prism placed in front of the eye-piece, between the latter and the observer's eye. If measures are made by placing the image of a star in the centre of the disk of a planet, the observer may have a tendency to do so systematically in error from some acquired habit or from natural astigmatism of the eye. But by rotating the prism 90° the image is presented entirely reversed to the eye, so that in the mean of measures made in two such positions personal error is eliminated. Similarly the prism may be used for the study and elimination of personal errors depending on the angle made by a double star with the vertical. The best plan of mounting such a prism has been found to be the following. I, I' (fig. 37) are the eye lens and field lens respectively of a Merz positive eye-piece. In this construction the lenses are much closer together and the diaphragm for the eye is much farther from the lenses than in Ramsden's eye-piece. The prism p is fitted accurately into brass slides (care has to be taken in the construction to place the prism so that an object in the centre of the field will so remain when the eye-piece is rotated in its adapter). There is a collar, clamped by the screw at S, which is so adjusted that the eye-piece is in focus when pushed home in its adapter, to this collar. The prism and eye-piece are then rotated together in the adapter

Fig. 37.

On the theory of the heliometer and its use consult Bessel, *Astronomische Untersuchungen*, vol. i.; Hansen, *Ausführliche Methode mit dem Fraunhoferschen Heliometer auszustellen*, Gotha, 1827; Chauvenet, *Spherical and Practical Astronomy*, vol. ii. pp. 403–456, Philadelphia and London, 1876; Seeliger, *Theorie des Heliometers*, Leipsic, 1877; Lindsay and Gill, *Dunecht Publications*, vol. ii., Dunecht (for private circulation), 1877; Gill, *Memoirs of the Royal Astronomical Society*, vol. xlvi. pp. 1–172.

Micrometers which Involve the Employment of the Diurnal Motion.

Advantage is often taken of the diurnal motion to measure the relative positions of stars. The varieties of reticules and scales that have been employed are far too numerous even for mention in detail. The following are the means and methods by which most work has been done, and they are typical of all the others. In the focus of his meridian telescope Lacaille had a brass diaphragm in which was cut a hole, having parallel, sharp, straight edges of the shape shown in fig. 38. The longer diagonal of the rhomboid so formed was at right angles, and the shorter parallel, to the diurnal motion. The method of observation consisted in noting the instant of ingress and egress of each star which presented itself. The mean of the times thus noted for each star gave the time of its transit over the imaginary line ab, whilst the difference between the instant of ingress and that of egress (converted into arc by the known approximate declination) gave the length of the chord traversed by the star parallel to the imaginary line cd. Hence (the dimensions of the rhomboid being known) the difference of the star's declination from the line cd became known (the observer was of course careful to note whether the star passed to north or south of cd). Thus every star that crossed the field was observed, all their right ascensions were referred to the clock-time of passing ab, and all their declinations to that of cd; hence their mutual differences of right ascension and declination were known. In this way, in the short space of ten months, Lacaille observed nearly ten thousand stars at the Cape of Good Hope in the years 1751–52.[5] Fraunhofer's ring micrometer consists of a ring of steel, very truly turned, mounted in a hole cut in a circular disk of glass. The ring is placed in the focus of a telescope, and viewed by a positive eye-piece. The observer notes the instants when the two objects enter and emerge from each side of the ring. The only data required for computing the difference of right ascension and declination of the two objects are the times above mentioned, the diameter of the ring, and the approximate declination of one of the objects. The latter is always known. The methods of determining the former and of reducing the observations are to be found in every work on practical astronomy. The ring micrometer has been largely used in observing comets.

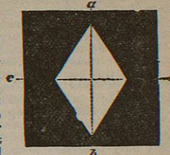

Fig. 38.

Argelander, in making his famous survey of the northern heavens,[6] employed a semicircle of glass, the straight edge of which (truly ground) crosses the centre of the field of view at right angles to the diurnal motion of the stars. Differences of right ascension were directly observed at this edge, whilst differences of declination were noted by strong dark lines drawn at right angles to the edge at each 10′ of arc. A telescope of 3 inches aperture with a magnifying power of 10 diameters commanded a field of 3° 20′ in declination. One observer was placed at the telescope, another at the clock. The telescope observer marked the instant when the star touched the glass edge, by calling sharply the word "eight" or "nine," &c., which also indicated the magnitude; the same observer also noted and recorded the reading of the declination scale (where the star crossed it), without removing his eye from the telescope. The clock observer wrote down the magnitude called out by the telescope observer, and the instant by the clock when the word was given. The two records were then compared after the observations of the night were over. In this way Schönfeld and Krueger (Argelander's assistants) observed and catalogued about three hundred thousand stars. The probable error of an observation is about ±0·7 sec. in right ascension and ±0″·4 in declination.

Bond[7] employed a very similar arrangement, differing only from Argelander's in having the scale cut on a sheet of transparent mica $\frac{1}{1000}$th of an inch in thickness. Very oblique illumination was employed, and the divisions and figures were seen bright upon a dark background. The range of declination was limited to 10′, the scale was divided to 10″, the right ascensions were observed by chronographic registration, and the great refractor of the Cambridge U. S. Observatory (with an aperture of 15 inches and power of 140) was employed. The probable errors in right ascension and declination were found to be ±0·06 sec. in right ascension and ±0″·6 in declination—results of marvellous accuracy considering the amount of work accomplished in a short time and the faintness (eleven to twelve magnitudes) of the stars observed.

We were on the point of criticizing Bond's programme as somewhat too ambitious for realization without cooperation (it would take about twenty-six thousand hours of observing to carry out the scheme for the northern hemisphere alone) when we received from Peters of Clinton, U. S., the first twenty maps of a series which will include the whole of the sky between declination +30° and −30°. If we consider that all the stars in these maps of the eleventh magnitude or brighter have been observed by a method similar to Bond's, that the enormous additional labour of frequent revision has been undertaken, and all stars visible with a power of 80 in a telescope of 13 inches aperture (about fourteenth magnitude) have been filled in

[1] Screws, as Auwers's discussion of Bessel's observations ("Parallaxe von 61 Cygni." *Abhandlungen der Königl. Akad. der Wissenschaften zu Berlin*, 1868) has shown, are apt to wear and change their errors. It is, besides, undesirable to apply force and friction to a delicate standard of measure.

[2] *Astron. Nachrichten*, No. 1416.

[3] For example, in determining the diurnal parallax of a planet the most favourable conditions are limited on the one hand by the uncertainties of refraction at large zenith distances, and on the other by the small parallax factors of small zenith distances. It would probably be best to secure all the observations between 50° and 60° ZD, and this would only be possible with special facilities for reading the scales.

[4] *Monthly Notices R. A. S.*, vol. xxx. p. 46.

[5] Lacaille. *Coelum Australe Stelliferum*, Paris. 1763, and *A Catalogue of 9766 Stars, from Observations of Lacaille*, London, 1847.

[6] *Atlas des Nördlichen Gestirnten Himmels*, Bonn. 1863, Introduction.

[7] *Annals of the Astronomical Observatory, Harvard College*, vol. i. part II.

by alignment, *and that all this results from the unaided labour of a single observer*, we find that our ideas of *the possible* have to be modified, when such a man undertakes a work with persistent unity of purpose for more than twenty years (1860–83).

There is an ingenious mode of registering differences of declination that has been in use at the Berlin Observatory since 1879, and is described by Dr Knarre in the *Zeitschrift für Instrumentenkunde* for July 1881. The instrument is called a declinograph. It has a web moved in declination by a quick-acting screw; the same screw carries a travelling pricker or point. The observer having bisected a star by the wire has simply to compress an india-rubber ball connected by a flexible tube with a thin metal box made on the principle of the vacuum chamber of an aneroid barometer. The expansion of this box so produced brings a sheet of paper in contact with two prickers, one the movable pricker before mentioned, the other a fixed pricker. The action of the vacuum box also automatically shifts the paper (a long roll) by a small quantity at each observation, so that successive observations are recorded in regular order. To obtain the observed differences of declination it is then only necessary to measure with a glass scale (divided for the special telescope to 10″) the distance of each record of the moving pricker from the fixed pricker. It is found, with this declinograph on the Berlin equatorial, that the observed declinations have only a probable error of ±0″·9. It is obvious that by using a chronograph in conjunction with this instrument both right ascensions and declinations could be recorded with great accuracy and rapidity.

Miscellaneous Micrometers.

Parallel glass micrometer.

Clausen in 1841 (*Ast. Nach.*, No. 414) proposed a form of micrometer consisting of a divided plate of parallel glass placed within the cone of rays from the object-glass at right angles to the telescope axis. One half of this plane remains fixed, the other half is movable. When the inclination of the movable half with respect to the axis of the telescope is changed by rotation about an axis at right angles to the plane of division, two images are produced. The amount of separation is very small, and depends on the thickness of the glass, the index of refraction, and the focal length of the telescope. Secchi (*Comptes Rendus*, xli., 1855, p. 906) gives an account of some experiments with a similar micrometer; and Porro (*Comptes Rendus*, xli. p. 1058) claims the original invention and construction of such a micrometer in 1842. Clausen, however, has undoubted priority. Helmholtz in his "Ophthalmometer" has employed Clausen's principle, but arranges the plates so that both move symmetrically in opposite directions with respect to the telescope axis. Should Clausen's micrometer be employed as an astronomical instrument it would be well to adopt the improvement of Helmholtz.

Ghost micrometer.

Burton and Grubb (*Monthly Notices*, vol. xli. p. 59), after calling attention to Lamont's paper (*Jahrbuch der K. S. b. München*, p. 187) and Littrow's paper (*Proc. of Vienna Acad. of Sciences*, vol. xx. p. 253) on a like subject, proceed to describe a most ingenious form of "Ghost Micrometer," in which the *image* of a fine line or lines ruled in (or rather cut through) a silver film deposited on glass is formed at the common focus of an object-glass and eye-piece of a telescope. A faint light being thrown on the outside of the silvered plate, there appear bright lines in the field of view. We have not had an opportunity of testing this, nor Grubb's more recent models; but, should it be found possible to produce such images satisfactorily, without distortion and with an apparatus convenient and rigid in form, such micrometers will probably supersede the filar micrometer. Their absolute freedom from diffraction, the perfect control of the illumination and thickness of the lines, and the accuracy with which it will be possible to construct scales for zone observations will be important features of the new method.

For the use of micrometers in connexion with the microscope, see p. 277 of the present volume. (D. GI.)

MICRONESIA. The term "Micronesia" embraces that region of the Pacific north of the great Melanesian islands, where, either perhaps from a greater or more rapid subsidence, or from the decreasing activity northwards of the coral builders, the islands become, generally speaking, smaller and fewer, and finally cease. Accordingly, excepting the Marianas or Ladrones, which are of volcanic origin, and a few isolated instances of elevation in the Carolines, the Micronesian islands, though many of the groups cover a vast area, are almost without exception very small low coral (atoll) formations. Besides the Ladrone and Caroline Islands (*q.v.*) Micronesia includes the Marshall and Gilbert groups, and some geographers include the Anson group, a number of small widely scattered islets to the west of Hawaii, the Magellan group farther west, and the Bonin Islands north of the Ladrones.[1]

North-easterly winds prevail during the winter months over the Marshalls, Ladrones, and Carolines, except in the extreme west, while between May and September the influence of the monsoon causes unsettled weather from the west, with heavy gales. In the Gilberts the south-east trade-wind brings fine weather at this season.

The ethnological features of Micronesia are much more definite than the geographical, for its populations form one great branch of the fair Polynesian race, distinguished from the other by well-marked differences in appearance, language, and institutions. Its ethnological relations are not thoroughly understood. The proximity of Japan and the Philippines on the west and of the Papuan and South Polynesian islands on the south and south-east suggests, what in fact we find, a combination of elements in different degrees of fusion. In some places the oblique Mongolian eye is noticed, and (along with certain Indo-Chinese customs) there is often a scantiness of beard and general "Malay" look which increases westwards, and seems to imply relations with the archipelago subsequent to the departure thence of the pure Polynesians. In the Gilberts the traces of Polynesian (Samoan) influences are evident, and are confirmed by tradition. Among the Carolines and the Marshalls darker and more savage communities are found, suggesting a Melanesian element, which is further traceable in the Ebon (Marshall) and other languages.

Each of the four groups, from long isolation, has developed peculiarities of its own. The most advanced were the "Chamorros" of the Ladrones, owing to the greater natural resources of the islands, and perhaps more frequent contact with influences from the west; but as a separate people they no longer exist, having been nearly exterminated by the Spaniards in the 17th century. Next in advancement come the Carolines. The general type is a well-proportioned rather slightly built figure, with small and regular features; head high and well-proportioned, but forehead rather retreating, and narrow at the temples; cheek bones and chin slightly prominent; colour somewhat darker than the Polynesians, the Marshalls being darker and more vigorous than the Carolines, while the Gilbert type is still darker and coarser. The upper class greatly surpasses the common people in physique and intelligence.

There is a peculiar division of society into septs or clans, the membership of which constitutes the closest tie. Persons of the same sept must not intermarry, and when two islands or communities meet in war the members of one sept, however widely separated by distance of space or time, will not injure or fight with each other. Each community is usually composed (but there are local differences) of—(1) an upper class of chiefs, from among whom the head (*tamol* or *iros*) is chosen; (2) a lower but still noble class; and (3) common people, mostly without rights of property. These last are only allowed one wife. Assemblies of the chiefs everywhere limit the kingly authority. In the Marshalls the sovereign has lost his control over many of the atolls, and in the Gilberts the above distinctions have nearly disappeared; the headship has lapsed, and, especially in the southern islands, the man of largest substance is the most powerful, and sometimes establishes a local supremacy. Here and there are traces, as in Tonga, of a spiritual sovereign, the descendants probably of a conquered dynasty. Succession is through the female side, which assures to women a certain position, and leads besides to some curious results (see paper by Kubary in *Das Ausland*, 1880, No. 27). The upper class are the keepers of traditions, boat-builders, leaders of expeditions; tattooing is generally done by them, the amount increasing with a man's rank; the custom here still has definite religious associations. Both sexes are tattooed. The people are singularly amiable and well disposed, but will repay ill usage with treachery. The women (although chastity is not expected before marriage) are somewhat more moral than the Polynesians, and are treated with respect, as are the aged. The natives are polite and hospitable to strangers (except on the poorer and ruder islands), bright and intelligent, active traders, expert cultivators and fishermen. They have a hand-loom from which beautiful fabrics of banana, hibiscus, and other fibres are produced. The Marshall Islanders are the boldest and most skilful navigators in the Pacific. Their voyages of many months' duration, in great canoes sailing with outrigger to windward, well-provisioned, and depending on the skies for fresh water, help to show now the Pacific was colonized. They have a sort of chart, *medo*, of small sticks tied together, representing the positions of islands and the directions of the winds and currents. A two-edged weapon, of which the blade is of sharks' teeth, and a defensive armour of braided sennit, are also peculiar to the islands; a large adze, made of the *Tridacna gigas*, was formerly used in the Carolines, probably by the old builder race.

The languages of Micronesia, though grammatically alike, differ widely in their vocabularies. They have the chief characteristics of the Polynesian, with Malay affinities, and peculiarities such as the use of suffixes and inseparable pronouns and, as in Tagal, of the infix to denote changes in the verb; in the west groups there is a tendency to closed syllables and double consonants, and a use of the palatals *ch*, *j*, *sh*, the dental *th*, and *s* (the last perhaps only in foreign words), which is alien to the Polynesian. These letters are wanting in the Gilbert language, which differs considerably from all the others, and has much greater affinities with the Polynesian.

The religious myths are generally identifiable with the Polynesian, but a belief in the gods proper is overshadowed by a general deification of ancestors, who are supposed from time to time to occupy certain blocks of stone, set up near the family dwelling, and surrounded by circles of smaller ones. These stones are anointed with oil, and worshipped with prayer and offerings, and are also used for purposes of divination, in which, and in various omens, there is a general belief. In the Marshalls, in place of these stones, certain palm trees are similarly enclosed. The spirits also sometimes inhabit certain birds or fishes, which are then *tabu*, as food, to the family; but they will help to catch them for others. All this closely recalls the *karwars* or ancestral images of New Guinea. Temples are very rare, though these blocks of coral are sometimes surrounded by a roofless enclosure opening to the west. The bodies of the dead, and sometimes even of the sick, are despatched to sea westwards, with certain rites; those of the chiefs, however, are buried, for the order has something essentially divine about it; their bodies therefore are sacred, and their spirits naturally assume the position above described. Such a belief greatly strengthens the king's authority, for the spirits of his ancestors are necessarily more powerful than any other spirits. Thus too it comes that the chiefs, and all belonging to them, are tabu as regards the common people. There are various other subjects and occasions of tabu, but the institution has not the oppressive and all-pervading character which it has in Polynesia. Its action is often economical or charitable, *e.g.*, the ripening cocoa-nuts are tabu as long as the bread-fruit lasts, thus securing the former for future use; or it is put on after a death, and the nuts thus saved are given to the family—a kindness to them, and a mark of respect for the dead.

The flora of the Gilbert and Marshall groups is of the usual oceanic character, with close Indo-Malay affinities. It is much poorer than that of the Carolines,[1] with its Moluccan and Philippine elements, and this again is surpassed by that of the Ladrones. In the Gilberts the scattered woods of cocoa-palm and *Pandanus* have little undergrowth, while the south Marshalls, being within the belt of constant precipitation, have a dense growth of (mostly) low trees and shrubs, with here and there a tropical luxuriance and variety unusual on atolls. The *Pandanus* grows wild profusely, and is of exceptional importance, being the chief staple of food, so that the cocoa-nut, which, however, flourishes chiefly in the Gilberts, is used mainly to produce oil for exportation. The bread-fruit grows chiefly in the south Marshalls. The taro (*Arum cordifolium* and others) is cultivated laboriously, deep trenches being cut in the solid rock for its irrigation, but this and other plants of cultivation, and indeed the vegetation generally, fall off in number and quality northwards. Various vegetables are grown on soil imported for the purpose. Marine plants are rare. Wilkes found on Makin Island, Gilbert group, a "fruit resembling the gooseberry," called "teiparu," from which a preserve is made. This seems very like the tipari or Cape gooseberry of India (*Physalis peruviana*). And their *karaka*, a drink made from the sap of the flower-stalk of the cocoa-palm (unfermented before the arrival of Europeans), recalls the arrack of southern Asia.

The fauna, like the flora, becomes poorer eastwards, birds being much more numerous on the high islands than on the atolls, where the few are chiefly aquatic. On Bonabe (Puynipet) out of twenty-nine species eleven are sea birds, and of the remaining eighteen seven are peculiar to the island. From the Pelews fifty-six species are recorded (twelve peculiar), and from the neighbouring Mackenzie group (Ulithi) twenty (six peculiar). Yet curiously no species is recorded common to these two groups and peculiar to them. The common fowl is found everywhere, wild or tame, and in some places is kept for its feathers only. The rat and a *Pteropus* are the only indigenous land mammals. The Indian crocodile is found as far east as the Pelews. There are five or six lizards, including a *Gecko* and *Ablephorus*. Insects are numerous, but of few kinds. Scorpions and centipedes are common, but are said to be harmless.

The houses in the Gilberts and Marshalls (much less elaborate than in the Carolines) consist merely of a thatched roof resting on posts or on blocks of coral about 3 feet high, with a floor at that level, which is reached from an opening in the centre. On this the principal people sleep, and it serves as a storehouse inaccessible to rats, which infest all the islands.

The Marshall archipelago consists of two nearly parallel chains of atolls, from 100 to 300 miles apart, the west known as Ralik, the east as Ratak. They lie between 4° 30′ and 12° N., and between 165° 15′ and 172° 15′ E., and run about N.N.W. and S.S.E. They were discovered in 1529 by Saavedra, who, observing the fine tattooing of the inhabitants (the first allusion to the practice in the Pacific), called them Los Pintados. Among modern voyagers Wallis first visited them in 1767; Captains Marshall and Gilbert reached them in 1788, and Kotzebue (1816) explored them more thoroughly. Each group contains fifteen or sixteen atolls, which range from 2 to 50 miles in circumference. An anomalous feature is reported on some of them, viz., that the greater proportion of land, or at all events of soil, is not found as usual on the windward side of the lagoon, for the prevailing north-east wind sweeps, it is said, the materials of which the soil of such islands is composed across to the lee side. Jaluit Island is the commercial emporium of the whole region. There is a curious tradition on Ebon Island of the Darwinian fact that the atoll once formed the barrier reef of an island now sunk beneath the lagoon. The population of Ratak is about 6000, of Ralik 4000; there is little intercourse between the two groups.

The Gilbert archipelago, discovered by Byron in 1765, is geographically a south continuation of the Marshalls, the channel separating them being 50 leagues wide. It lies between 2° 40′ S. and 3° 20′ N., and between 172° 30′ and 177° 15′ E., and contains sixteen atolls, not including two hilly islands, Banaba and Nawodo, which lie 5° to 6° to the west. Several have good anchorages inside the lagoon, with entrances on the lee side. On some the lee or west reef is wanting, owing to the abrading force of the west storms. During these large trees are washed ashore, their roots containing pieces of fine basalt, of which implements are made. There is a far larger proportion of land to submerged reef and lagoon than in the Marshalls, the land sometimes rising 20 feet above the sea, whereas in the Marshalls the average level of the reef rock is less than a foot above the surface; but, though the supply of fresh water is exceptionally great, in fact enough for the luxury of a bath, the soil (especially in the south) is very much less productive. Yet the population, about 50,000, is exceptionally dense. The usual scattered houses are replaced by compact rows of roofs which, shaded by cocoa-palm, and each with its boat-shed below, line the shore. Their numbers are unchecked either by the constant practice of abortion or by fighting, to which they are much addicted, their weapons being more formidable than those of their neighbours. This exceptional vigour may be due to the decidedly hybrid character of the race. Hawaiian missionaries, under American superintendence, have laboured here since 1857.

See also Findlay's *Sailing Directions for the North Pacific*; Roper's *North Pacific Pilot and Nautical Magazine*, vols. xxxi. and xxxv. Other authorities are Gerland in *Watte's Anthropologie der Naturvölker*, vol. v.; Meinicke, *Die Inseln des Stillen Oceans*; Hale's *Ethnography and Philology of Wilkes's U. S. Exploring Expedition*; Kotzebue and Chamisso, *Entdeckungsreise in die Südsee*: *Proc. Zool. Soc.*, 1872 and 1877. (C. T.)

[1] These islands, which contain a mixed immigrant population, are claimed, and have been recently surveyed, by Japan. But they were annexed to England by Captain Beechey in 1827. (See Von Kittlitz, *Denkwürdigkeiten einer Reise nach . . . . Mikronesien*, &c., vol. ii.)

[1] About 180 species have been observed on Kusaie, one-fourth of all the plants being ferns.

MICROPHONE. See Telephone.